REVISED PROTOCOL FOR AIR DISPERSION AND DEPOSITION MODELING OF POLLUTANT EMISSIONS FROM THE NEPERA INCINERATOR, HARRIMAN, NEW YORK

Prepared for

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September 30, 1994

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1 Introduction

This document outlines the methodologies and assumptions proposed for conducting an air dispersion and deposition modeling study of pollutant emissions released from the hazardous waste incinerator operated by Nepera, Inc. at its production facility in Harriman, New York. The proposed work builds upon studies prepared by Four Nines, Inc. (1992) and Cambridge Environmental Inc. (1994) that have been submitted to the New York State Department of Environmental Conservation (NYSDEC). Relevant sections of the original air dispersion modeling protocol developed by Four Nines, Inc. (1992) are contained in Appendix A. Similar sections will also be included in the final modeling report to create a complete, self-referencing document.

The remainder of the revised protocol is organized into two major parts. Section 2 summarizes the previous work of Four Nines, Inc. (1992) and Cambridge Environmental Inc. (1994). Conclusions from this previous work motivate and justify the modeling approach proposed in Section 3. Also included in Section 3 are responses to specific comments offered by NYSDEC regarding air dispersion modeling (see Appendix B).

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2 Previous Work

Four Nines, Inc. (1992), working interactively with guidance from NYSDEC, prepared and submitted a detailed air dispersion modeling protocol for the Nepera Incinerator. The Four Nines protocol identified two models — ISCST2 and COMPLEX1 — as appropriate for the study. The ISCST2 model was selected to evaluate pollutant concentrations at receptors in simple terrain (*i.e.*, at elevations lower than stack-top). ISCST2 is a refined regulatory model (as designated by the U.S. EPA [1993]) capable of accounting for aerodynamic influences of buildings near the stack, and hence was both appropriate and advantageous for evaluating plume dispersion for the Nepera incinerator. The valley setting of the Nepera facility, however, limits the applicability of the ISCST2 model, since terrain elevations rise above stack-top within a mile of the facility. The COMPLEX1 model was therefore selected to evaluate pollutant concentrations at receptors with base elevations above plume centerline height. The lack of on-site meteorological data required the COMPLEX1 model to be applied in Valley Mode (hereafter referred to as COMPLEX1-VM), which utilizes worst-case meteorological conditions.

Key features of the Four Nines, Inc. (1992) protocol are the following.

- **Land use identification**
  The Simplified Land Use Process was used to assess land use within a three kilometer radius about the stack location. This process considers color-coding and other features identifiable on topographical maps to differentiate rural and urban land use in the vicinity of the facility. Using these procedures, a rural classification was chosen for the determination of dispersion coefficients in the modeling study. A description of the land use analysis is included in Chapter 8 of the Four Nines, Inc. (1992) protocol, which is provided in Appendix A.

- **Receptor definition and terrain analysis**
  A polar modeling grid was established with 33 radial distances ranging from 55 m to 5 km from the stack. A series of 36 equally spaced receptors was placed at each radial distance. Except for the initial 55-m distance, radials were spaced on equal 100-m intervals from 100 m out to 2 km. From 2 km to 5 km, radials were spaced 250 m apart.

  Terrain elevations for the 1,188 receptors were determined from topographical maps published by the U.S. Geological Survey. In addition, the topographical maps and area surveillance were used to identify the locations and elevations of nearby residences, multi-story buildings, and other receptors of interest (hospitals, schools, *etc.*).

  Descriptions of receptor identification and terrain analysis are contained in Appendix A (Chapters 9, 10, and 11).

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- **Meteorological data**
  Meteorological data from nearby airports and surface weather stations were evaluated (with guidance from NYSDEC) to identify the most appropriate data for use with the ISCST2 model. Data collected at Stewart Air Force Base in Newburgh, New York, were selected for surface observations, and combined with upper air data collected at the Albany Airport. A five-year data set for the 1964–1968 period was provided to Four Nines, Inc. by NYSDEC.

  The procedures used to identify and select meteorological data are described further in Chapter 12 of the Four Nines, Inc. (1992) protocol (a copy of which is included in Appendix A).

- **Stack parameters**
  Physical stack parameters, including base elevation, present stack height, and inner stack diameter, were determined from engineering drawings of the Nepera facility. Stack gas parameters, including exit temperature and flow velocity, were determined from process operating conditions of the incinerator. Further descriptions can be found in Chapter 7 of the original modeling protocol (Four Nines, Inc., 1992), which is included in Appendix A.

- **Building downwash analysis**
  Information from maps of the Nepera facility was used to evaluate potential aerodynamic influences on plume dispersion. Using U.S. EPA methodologies, building locations and dimensions were used: (1) to identify buildings of possible importance to plume downwash, and (2) for those buildings determined to be relevant, to estimate minimum Good Engineering Practice (GEP) stack heights. Building orientations and dimensions were also used to assign direction-specific height and width inputs for the ISCST2 model. Information relevant to building downwash and the determination of GEP stack height is found in Appendix A, which contains sections from the original modeling protocol (Four Nines, Inc., 1992). Specific methods are described in Section 5.1 of the Four Nines, Inc. (1992) report, with reference the Nepera site plot plan and roof elevation map (also included in Appendix A).

- **Cavity analysis**
  Due to limited height of the present stack (70 feet) relative to nearby buildings, a cavity analysis was required to estimate worst-case short-term pollutant concentrations. The cavity analysis revealed that a modest increase in stack height would be necessary to avoid cavity effects. The cavity analysis is contained in Section 5.2 of the Four Nines, Inc. (1992) protocol, which is included in Appendix A.

Cambridge Environmental Inc. (1994) implemented the majority of the Four Nines, Inc. (1992) modeling protocol in the July 27, 1994 Preliminary Health Risk Assessment (PHRA) of the

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Nepera Incinerator (which has been submitted to NYSDEC *per* the requirements of the compliance schedule). A key assumption of the PHRA was an assumed stack height of 152 feet, which corresponds to the minimum GEP height identified in the Four Nines protocol. The results of the dispersion modeling are summarized in Figure 2.1 to Figure 2.4.

Figure 2.1 is a map of terrain elevations for receptors within the polar modeling grid, as determined by Four Nines, Inc. (1992). The color-coded categories relate elevations to the assumed GEP stack height utilized in the PHRA study. Black symbols indicate terrain elevations lower than the base of the stack of the Nepera Incinerator. These locations occur near the facility to the south and east (generally along the Ramapo River Valley). A second area of low terrain exists at distance of 2–3 km northeast of the facility.

Green symbols indicate terrain elevations between the base and top of the incinerator stack. These receptors are situated in the valleys northeast, northwest, and south of the Nepera facility. Potential complex terrain receptors are indicated by blue, red, light blue, and magenta symbols, in order of increasing elevation ranges. Within the study region, the highest elevations are located to the east and east-southeast of the facility. Additional areas of elevated terrain are located to the north and southwest. These three regions of complex terrain are separated by the lower-lying valleys. As described below in Section 3, these areas of elevated terrain motivate the modification proposed here for the air dispersion study.

Air pollutant concentrations predicted by the ISCST2 and COMPLEX1-VM models are depicted in Figure 2.2 and Figure 2.3, respectively. The ISCST2 predictions are considerably smaller in magnitude than the predictions of the COMPLEX1 model. The ISCST2 predictions, however, are only applicable at a fraction of the receptor locations.[1] The highest predicted impacts, which occur at complex terrain receptors, are generated by the COMPLEX1-VM model (Figure 2.3). These highest impacts occur at the three terrain features described above at distances of about 2 km from the stack. Predicted concentrations decrease with distance beyond 2 km from the stack, demonstrating that the modeling domain is of adequate extent to identify the maximally impacted areas.

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[1] Both Figure 2.2 and Figure 2.3 present model predictions at all receptors. As explained previously, however, the models apply selectively at different receptors based upon their elevation relative to plume height. An integration of the ISCST2 and COMPLEX1-VM modeling results is presented in the PHRA report.

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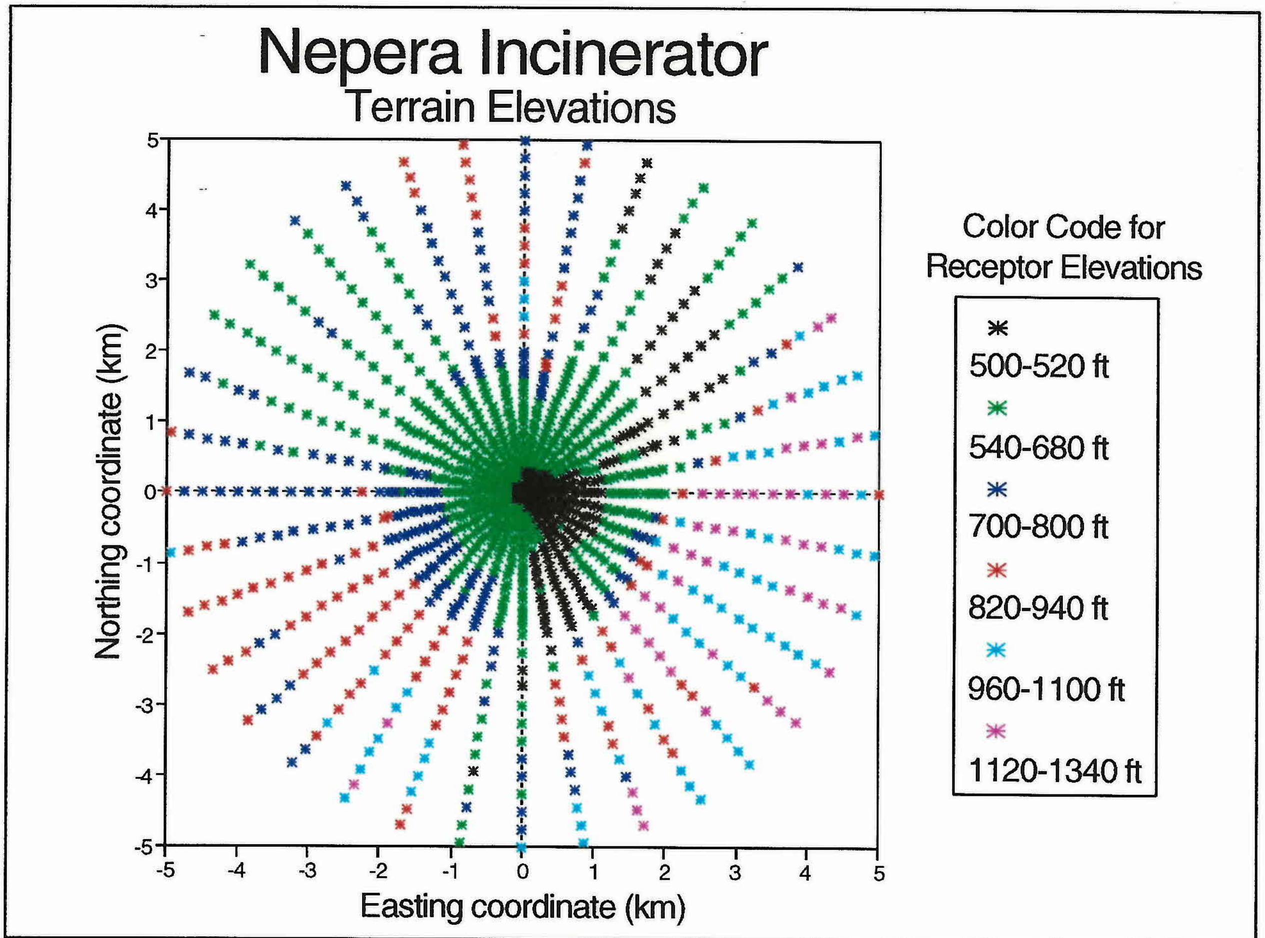

Figure 2.1 Receptor elevations relative to the Nepera Incinerator (located at the origin). Black symbols indicate elevations below stack base, green symbols those between base and GEP stack top, and others are above stack top. 1"= 2.7 km

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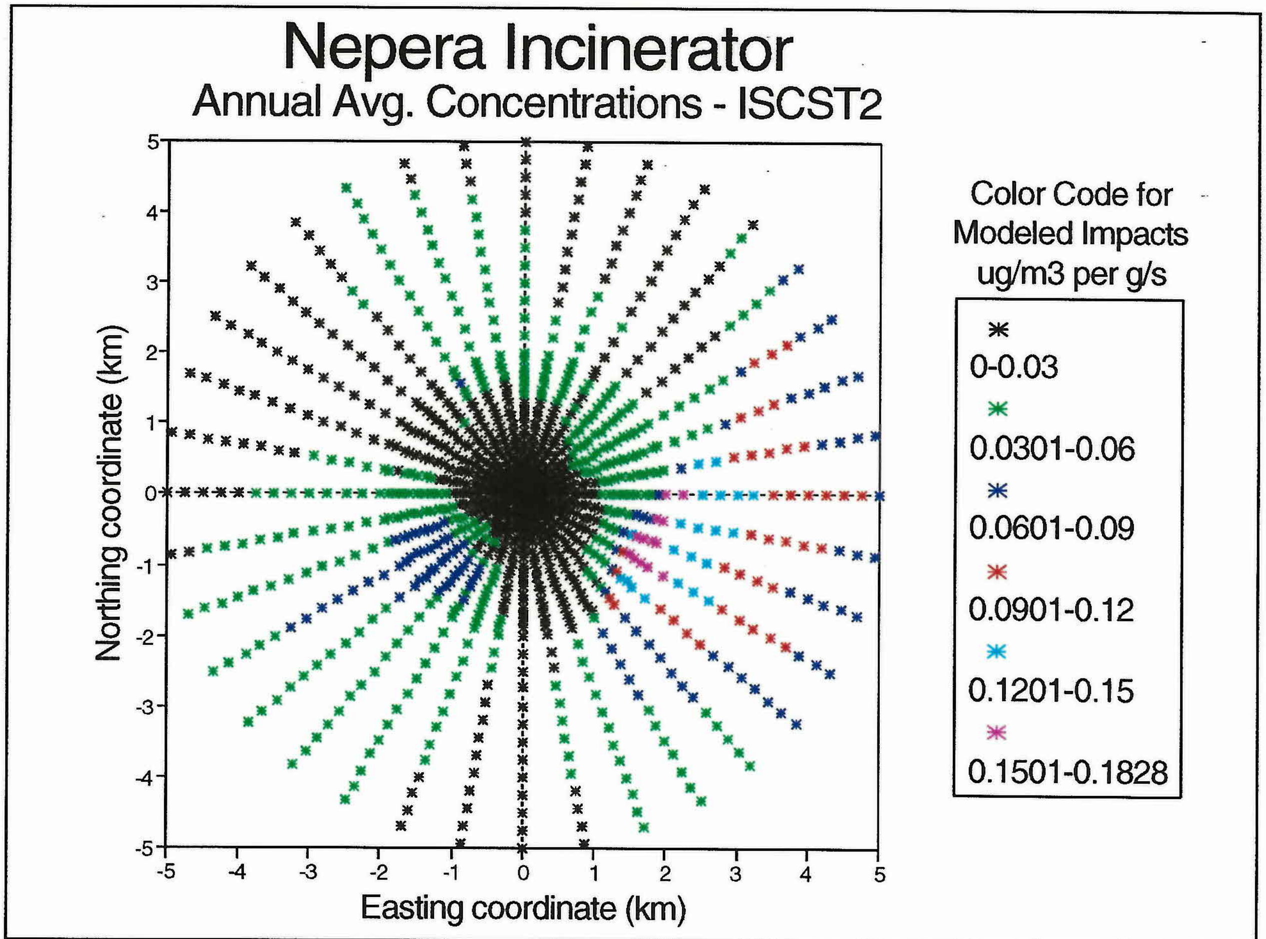

Figure 2.2 Annual average pollutant concentrations predicted by the ISCST2 model. Concentrations are normalized per a unit emission rate (*i.e.*, in units of $\mu g/m^3$ per g/s). Scale: 1" = 2.7 km

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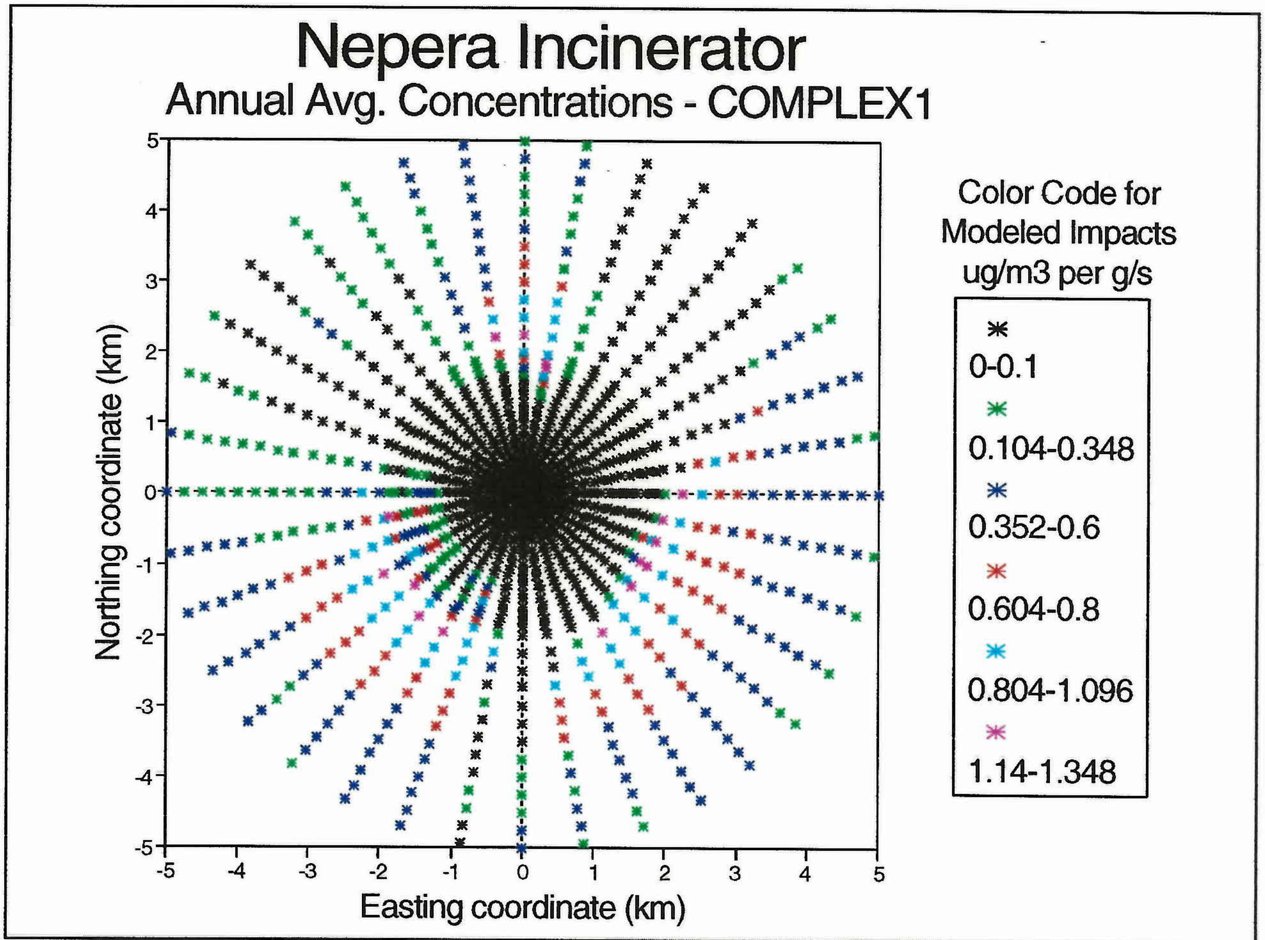

Figure 2.3 Annual average pollutant concentrations predicted by the COMPLEX1–Valley Mode model. Values are normalized to a unit emission rate (*i.e.*, in units of $\mu g/m^3$ per g/s). Scale: 1" = 2.7 km

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The COMPLEX1-VM model predictions are presented in a somewhat different manner in Figure 2.4. Here, the predicted airborne concentrations are plotted against receptor elevation, with the symbols stratified by color-coded ranges of source-receptor distance. Figure 2.4 emphasizes that the highest predicted concentrations occur within 1.5–3 km from the incinerator. Projected impacts at the edge of the modeling domain (4.25–5 km) are roughly 2½-times smaller than peak values. This factor lends justification to the revised modeling procedures described in Section 3.1.

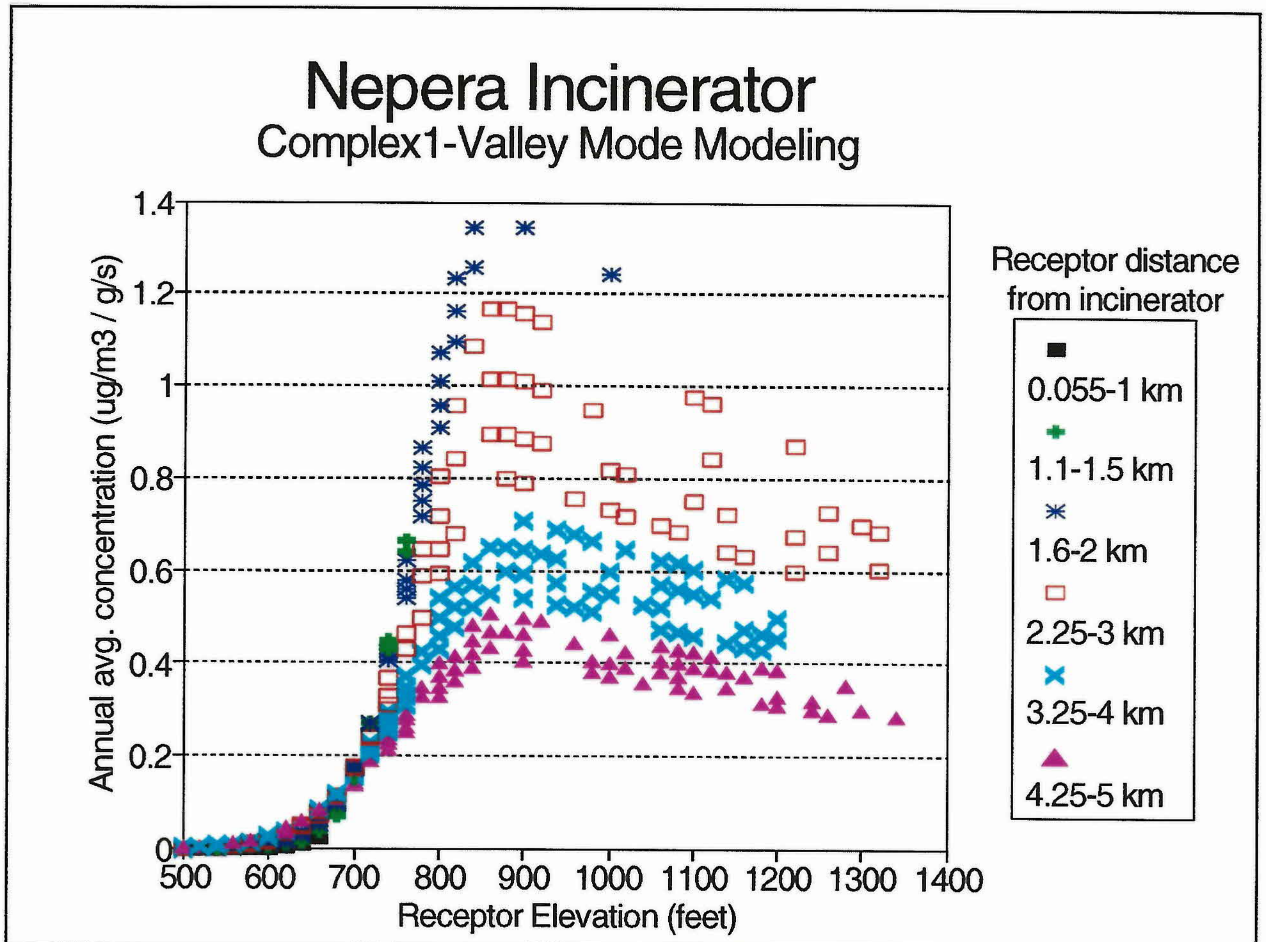

Figure 2.4 Annual average concentrations (in $\mu g/m^3$ *per* g/s, as predicted by the COMPLEX1–Valley Mode model) *vs.* terrain elevation. Symbols differentiate receptor distance from the source.

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3 Revised Protocol for the Air Dispersion Modeling Study

The proposed modeling study proposed for the risk assessment of the Nepera Incinerator differs somewhat from the analysis conducted within the PHRA. The principal revision is the use of a more sophisticated screening model — CTSCREEN — for assessing impacts at receptors in complex and intermediate terrain. CTSCREEN is endorsed by the U.S. EPA (1993) and, similar to COMPLEX1-VM, does not utilize actual meteorological data (predicting, instead, results from worst-case meteorological scenarios). The feature that distinguishes CTSCREEN from COMPLEX1-VM is its more detailed consideration of topographical features that enables more realistic estimation of plume travel and dispersion.

Aspects of the revised protocol for the air dispersion modeling are discussed in the following three sections. Section 3.1 describes the intended selection, application, and integration of dispersion models. Section 3.2 describes additional modeling assumptions to be investigated in the revised study. Finally, Section 3.3 addresses a number of specific concerns raised by NYSDEC. For reference, a copy of these comments is included in Appendix B.

3.1 Selection and application of models

A combination of three models — ISCST2, CTSCREEN, and COMPLEX1-VM — is proposed for the revised air dispersion modeling study. The models are to be applied as follows:

- receptors with elevations below stack-top will be evaluated with the ISCST2 model;
- receptors in intermediate/complex terrain at the three principal terrain features (as described in Section 2) will be evaluated with the CTSCREEN model;
- receptors in complex terrain (*i.e.*, those above plume centerline height) that lie outside of the three CTSCREEN modeling domains (if any) will be evaluated with the COMPLEX1-VM model; and
- receptors in intermediate terrain (*i.e.*, those above stack-top but below plume height) that lie outside of the three CTSCREEN modeling domains (if any) will be evaluated with both the COMPLEX1-VM and ISCST2 models, with the larger of the two predicted values adopted.

The general locations of the three CTSCREEN modeling domains are overlain on a topographical map in Figure 3.1. Selection of these three terrain features is justified by the results of the PHRA modeling study, which suggests that these features be treated as distinct hills. Also, the 5-km radius used in the PHRA modeling study will be maintained based upon the identification of the

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Figure 3-1 of this document is a color reproduction of a topographic map

It is identical to Figure 4.1 of the risk assessment report, to which the reader is referred

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peak modeled concentrations well within the modeling domain (as described and portrayed in Section 2).

The precise extents of the modeling domains will be determined from careful consideration of the topographic maps, following suggestions developed by the U.S. EPA (Schwede, 1993). The CTSCREEN model requires detailed topographic data, which will be constructed by digitizing contour elevations from U.S. Geological Survey maps of the region. The resolution of contour data will depend upon the specific pattern of each terrain feature. Initially, contours will be digitized at elevation increments of 100 feet. A sensitivity study will be performed to test the adequacy of this spacing. If necessary, additional contours will be digitized at smaller increments.

For reference, the relative orientation of the three principal terrain features is depicted in Figure 3.1. Also shown in Figure 3.1 is the extent of the study area (as indicated by the thick-lined circle). A single contour is highlighted for each terrain feature (labeled A, B, and C). These contours coincide with the areas of highest projected impact determined in the PHRA study. Both higher and lower elevations will be digitized for each feature. Preliminary estimates suggest the CTSCREEN modeling domains will encompass the majority of complex terrain within the 5 km study area.

The CTSCREEN model contains a module to facilitate the generation of a receptor grid that conforms to the digitized contours. This feature will be used to generate preliminary results. Additional (discrete) receptors will then be added to refine modeling estimates in the areas of highest projected impact. In these areas, receptor spacing will be 100 m or less (see also comments in Section 3.2.2).

The predictions of the ISCST2, CTSCREEN, and COMPLEX1-VM will be combined in the manner described above to generate a single, integrated picture of predicted impacts throughout the study region. Average impacts, which may be required for the evaluation of farming- and water-related exposure routes within the health risk assessment, will be evaluated by area-weighting the appropriate model predictions.

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3.2 Additional modeling assumptions

The intended treatment of several additional modeling aspects is discussed below.

3.2.1 Stack height considerations

The PHRA modeling study considered a single stack height (152 feet — the GEP height) that exceeds the current physical stack height. Elevation of the present stack height is anticipated. The extent to which the stack can be raised, however, may be limited by local ordinances, public concern over aesthetic issues, or other factors.

Consequently, it may be necessary to investigate dispersion using a range of stack heights. The ultimate choice of stack height will be determined on the basis of the above concerns, NYSDEC's policy (which encourages the use of GEP stack heights), and the consideration of health risk estimates.

3.2.2 Refined impact analysis

As pointed out by NYSDEC (Appendix B) and mentioned above, the PHRA modeling study did not refine the maximum impact location to within a distance of 100 m.[1] As described in Section 3.1, the revised study will use a sufficient number of receptors to locate the maximum impact point within a distance of 100 m.

3.2.3 Stack exit parameters

Stack gas exit conditions (temperature and velocity) affect the buoyancy of the plume, and can thereby influence plume dispersion and predictions of ground-level concentrations. For example, a reduction of stack gas velocity associated with low-load conditions can lead to reduced plume rise and a lesser degree of dilution. Since pollutant emission rates are generally lower under such conditions (assuming similar stack-gas concentrations), dispersion and emission factors compensate, and hence it is not readily apparent which conditions (full load or partial load) will lead to higher predictions of ground-level concentrations.

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[1] In the PHRA study, the maximum impact point was predicted at 2 km, the radial distance that served as the boundary between receptor rings spaced at 100 m and 250 m.

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Modeling in the PHRA used a single set of stack gas exit conditions, whereas two exit scenarios will be investigated in the revised modeling study. These scenarios will correspond to the high and low temperature operating regimes to be investigated in the trial burn.

3.3 Additional issues

A number of additional questions regarding the PHRA modeling study were raised by NYSDEC (see Appendix B for a copy of these comments).

3.3.1 Cumulative impacts from other hazardous waste incinerators

To our knowledge, no other hazardous waste incinerators operate either within the study region or in the more distant (30 km) vicinity of the Nepera Incinerator. A previous search (Four Nines, Inc., 1992) identified no other significant sources of hazardous air pollutants within a 10-km radius of the facility.[2]

A new search will be conducted, however, and the results presented in the risk assessment report. Should additional hazardous waste incinerators be identified, the influence of their emissions will be considered in both the air dispersion modeling study and the health risk assessment.

3.3.2 Additional maps

The revised air dispersion study will be described in detail in the final risk assessment report. Maps showing (1) the layout of the facility (including the location of the incinerator, adjacent buildings, and site boundaries) and (2) the topography of the region (depicting land use within a 3-km radius about the source) will be included.[3]

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[2] Documentation of this analysis is contained in Chapter 13 of the original air dispersion modeling protocol (Four Nines, Inc., 1992), a copy of which is included in Appendix A.

[3] Some of these maps have already been submitted to NYSDEC as part of the original air dispersion modeling protocol (Four Nines, Inc., 1992). For convenience, the relevant maps have been included in Appendix A. These maps will also be included in the final risk assessment report to eliminate the need to refer to multiple reports.

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3.3.3 Land use determination and building downwash analysis

As described in Section 2, analyses have already been conducted (1) to characterize the dispersion regime as rural (based upon local land use); and (2) to determine direction-specific building dimensions for use in the ISCST2 model. A color reproduction of the topographical map of the region is presented in Figure 3.1. Results of the land use analysis are described in Chapter 8 of the Four Nines, Inc. (1992) protocol, which is included in Appendix A. These materials will also be included in the risk assessment report.

3.3.4 Deposition modeling

Similar to the approach employed in the PHRA, deposition modeling will be treated as a supplemental analysis to the air dispersion study. The air dispersion study will be conducted under the assumption of no pollutant deposition, *i.e.*, no plume depletion. Subsequent to the dispersion modeling, ground-level predictions of airborne pollutant concentrations will be multiplied by appropriate deposition velocities to estimate rates of pollutant deposition. Air quality predicted by the dispersion modeling will hence be unaffected by the deposition modeling. Since concerns have been expressed about the deposition modeling assumptions used in the PHRA, however, the following response to specific comments are provided.

- As requested, further documentation is provided to justify the assumed particle size range of 0.1–1.0 µm and associated deposition velocities. Support for the particle size assumption can be found in many references on air pollution. Relevant excerpts from Wark and Warner (1981) and Seinfeld (1986) are included in Appendix C. Both of these references suggest that characteristic particle diameters from the Nepera Incinerator will range from 0.1–1.0 µm. Particles of this size form in combustor stack gases due to condensation and accumulation processes.

  The particulate deposition velocity of 0.1 cm/s derived in the PHRA is proposed for use in the deposition modeling study within the final risk assessment. Relevant pages from the PHRA describing the derivation of the 0.1 cm/s value are included in Appendix D. The deposition velocity was derived using methods developed by the California Air Resources Board (CARB, 1987). Using a variety of surface roughness heights (appropriate for wooded lands, open lands, and water surfaces) and local meteorological data, deposition velocities were developed as a function of particle size. The selected value of 0.1 cm/s is roughly a factor of two greater than the deposition velocities predicted by the CARB model over the 0.1–1.0 µm size range. Inclusion of the factor of two is a conservative measure designed to account for uncertainties in the analysis.

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- The fact that organic vapors deposit from the atmosphere is acknowledged.[4] The PHRA assumption that vapors fail to deposit to an appreciable extent is erroneous, and will be corrected in the final risk assessment. The consequences of the PHRA assumption, however, are likely to remain the same since the deposition of organic vapors is of little consequence to the health risk assessment. Unless evidence is found to the contrary, the final risk assessment will not consider gaseous deposition of volatile organic vapors because the compounds in question do not bioaccumulate to any significant degree following airborne deposition. For example, volatile compounds will not accumulate appreciably in soil over the long term simply because of their volatility — vapors that do deposit will tend to off-gas rapidly as the plume changes direction. Also, the gaseous deposition of many compounds occurs because of surface reactions that are not (in effect) deposition processes but rather destruction/removal processes that lend no appreciable opportunity for bioaccumulation.

  It is worthwhile to note again that the air dispersion modeling analysis is independent of the proposed treatment of deposition since the air dispersion models do not account for pollutant removal from the air layer. Hence, the predicted ground-level concentrations in air are not affected by deposition velocity assumptions. Analysis of deposition will lead to "double counting" of some portion of pollutant emissions, but is adopted because of the lack of suitable modeling algorithms that correctly account for plume depletion at the surface.

  A more complete justification for not quantifying the deposition of organic vapors will be provided in the risk assessment report. Again, however, it should be emphasized that deposition assumptions will not influence the results of the air dispersion modeling study because plume depletion is not factored into the computer models.[5]

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[4] All metals are treated as particle-borne in the PHRA deposition analysis. A similar assumption is intended for the future health risk assessment.

[5] From the standpoint of health risk assessment, the assumption of no significant deposition of volatile organic compounds is conservative, since ignoring plume depletion leads to overestimates of ground-level concentrations, which in turn leads to an overestimation of inhalation exposure (the principal route of exposure for volatile organic compounds).

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4 Deliverables

The results of the air dispersion modeling study will be documented in the final risk assessment report. In addition to the tables, maps, and descriptions that will be contained in the report, copies of model input files, model output files, and meteorological data will be submitted to NYSDEC on diskettes in PC-compatible format.

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5 References

Cambridge Environmental Inc. (1994). *A Preliminary Health Risk Assessment for the Nepera Incinerator, Harriman, New York.* Cambridge, MA: Cambridge Environmental Inc.

CARB (1987). Deposition rate calculations for air toxics source assessments. Memorandum issued by the California Air Resources Board, Sacramento, CA.

Four Nines, Inc. (1992). *Dispersion Modeling and Risk Assessment Protocol.* Plymouth Meeting, PA: Four Nines, Inc.

Seinfeld, J.H. (1986). *Atmospheric Chemistry and Physics of Air Pollution.* New York: John Wiley & Sons.

Schwede, D. (1993). Notes on terrain input to CTDMPLUS/CTSCREEN. SCRAM Bulletin Board Memorandum. Research Triangle Park, NC: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards.

U.S. EPA (1993). *Requirements for preparation, adoption, and submittal of implementation plans.* 40 CFR Parts 51, 52, 260 and 266.

Wark, K., and Warner, C.F. (1981). *Air Pollution: Its Origin and Control.* 2nd ed. New York: Harper-Collins Publishers

Appendix A: Excerpts from the Four Nines, Inc. (1992) Dispersion Modeling Protocol

The following pages are copied from the Air Dispersion Modeling and Risk Assessment Protocol developed by Four Nines, Inc. (1992) and previously submitted to NYSDEC.

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FOUR NINES, INC.

DISPERSION MODELING AND RISK ASSESSMENT PROTOCOL

NEPERA, INC.
HARRIMAN, NEW YORK
FACILITY EPA ID NYD002014595

PREPARED FOR
NEPERA, INC.
APRIL, 1992
REVISED SEPTEMBER, 1992

FOUR NINES, INC.
PLYMOUTH MEETING, PA 19462

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1. Introduction

The purpose of this modeling protocol is to establish the modeling procedure to be used to analyze the air quality impacts of emissions of metals and hydrogen chloride/chlorine from the incinerator owned and operated by NEPERA, Inc. The incinerator is located in Area 61 at the NEPERA plant in Harriman, New York. This analysis will satisfy requirements given in the EPA Guidance on Metals and Hydrogen Chloride Controls for Hazardous Waste Incinerators.

The EPA has proposed amendments to the hazardous waste incinerator rules which will regulate the emissions of metals and hydrogen chloride. The guidance manual gives a "tiered" series of standards based on health risks. These standards are designed to limit exposure of the maximum exposed individual to carcinogenic and noncarcinogenic metals and hydrogen chloride to acceptable levels.

This protocol will establish the procedures to be used for a "Tier III" analysis of the NEPERA incinerator. Tier III analysis is required in this case because of complex surrounding terrain. The terrain rises above the stack within a five (5) kilometer radius of the site. In complex terrain, Tiers I and II cannot be used because they may not produce conservative estimates. Tier III involves site specific modeling and risk assessment using procedures consistent with the EPA Guidelines on Air Quality Models (Revised).

The procedure that will be followed involves the use of the Industrial Source Complex Short-Term (ISCST) model and the COMPLEX I model in the "Valley equivalent" option to determine dispersion coefficients. The use of these models is recommended in the Guidelines on Air Quality Models and by the NYDEC.[1] This analysis will also be consistent with any New York State Department of Environmental Conservation (NYDEC) regulations in Air Guide-26.

2. Facility Description

NEPERA occupies a two parcel site in a generally rural area of Harriman, New York. The area surrounding the site is zoned for industrial use and neighboring owners have plans to construct additional industrial facilities. A site plan showing NEPERA's buildings and waste incineration area is included as Attachment 2. A layout of NEPERA property boundaries is included as Attachment 5.

The NEPERA Harriman facility consists of a liquid/fume incinerator with a waste heat boiler. The incinerator is designed to destroy process residue streams, process vent streams, and waste water from the facility. The total system heat release is estimated to be 90 MM BTU/hr.

The incinerator is a multi-fuel fired unit equipped with an 80 MM BTU/hr burner. The incinerator is designed to operate at a temperature range of 1800°F to 2500°F. At maximum operating conditions, the incinerator chamber provides approximately 1.1 seconds residence time at 1800°F.

The liquid waste streams are introduced through waste guns in the main burner and are atomized with steam or air. The aqueous waste is introduced through eight (8) aqueous waste guns radially located on the shell of the incinerator downstream of the main burner. All the vent streams enter the incinerator in the combustor section, except for the cyanopyridine vent stream, which is introduced through the burner and through the windboxes of the aqueous waste nozzles. Oxygen for combustion is provided by the combustion air fan or by a combination of the process vents and combustion air.

The incinerator combustion products exit the incinerator through breeching to the bottom inlet of a Deltak waste heat boiler. The boiler has a nominal rating of 50,000 lb/hr. At the design conditions, the boiler will cool the flue gases to approximately 625°F. The boiler exit gases rise vertically, exiting through a five (5) foot diameter stack. The current stack height is seventy (70) feet.

The General Arrangement drawing of the incinerator is given as Attachment 3.

5. Good Engineering Practice Stack Height

5.1 Stack Height Calculations

The Good Engineering Practice (GEP) Stack Height is defined in the EPA document Guideline for Determination of Good Engineering Practice (GEP) Stack Height. The following equation is given to determine the GEP stack height:

$$GEP(minimum) = H + (1.5 \times L)$$

$$GEP(maximum) = greater\ of\ 65\,\mathrm{m}\ or\ H + (1.5 \times L)$$

where

H = Height of nearby structure measured from ground level elevation at the base of the stack.

L = The lesser dimension of the height or projected width of nearby structure

To determine the GEP stack height, the dimensions of all nearby buildings are required. A building is considered nearby if it is within a distance of $5L$ of the stack. The building which results in the greatest GEP stack height is considered the controlling building in the area. This building will be used to determine the downwash effects in the ISC model. The nearby buildings are listed in Table 9. The building numbers correspond to the plant layout drawing given as Attachment 2.

Table 9

Nearby Buildings

Building	Projected Height (ft)	Width (ft)	Distance From Stack (ft)	5 * L (ft)
1A	60.8	159	71	304
1B	53.2	162	118	266
1	60.8	268	68	304
4	56.8	171	90	284
9	34.5	117	27	173
9A	29.0	55	27	145
9B	34.5	50	69	173
9C	19.1	53	67	96
9D	26.3	37	37	132
9E	18.0	27	22	90
10	30.6	65	148	135
35	26.0	34	60	130
71	13.5	40	45	68
81	13.5	24	45	68

Using the equations above, the GEP stack heights calculated for each building are given in Table 10. The minimum GEP height was determined using Building 1 which is the controlling building. The minimum GEP stack height is 152 feet. The actual stack height presently is 70 feet. NEPERA plans to increase the stack height to meet all NYDEC requirements. NYDEC Policy memo 92-AIR-18 promotes the use of GEP stack height. Preliminary calculations have shown that the stack will have to be increased to a minimum of 150 feet to meet regulatory guidelines. This value is approximately GEP height.

Table 10

GEP Stack Height

Building	**Stack Height (ft)**
1A	152.0
1B	133.0
1	152.0
4	142.0
9	86.3
9A	72.5
9B	86.3
9C	47.8
9D	65.8
9E	45.0
10	71.1
35	65.0
71	33.8
81	33.8

5.2 Cavity Analysis

Plume downwash occurs when the plume flows past a large structure and is entrained in an increased turbulent area downwind of the structure. The turbulent area is divided into two regions, the cavity region and the wake region. The cavity region usually extends a distance of two (2) to three (3) building heights downwind of the building. This area is characterized by low mean wind speeds, circular air motion and high turbulence. The wake region is immediately downwind of the cavity region and can extend a distance of five (5) to ten (10) times the building height. There is also high turbulence in this area although not as great as that found in the cavity region. A plume can become trapped in the cavity region if the stack height is less than one and a half times the building height. Pollutants which are entrained in the cavity region are frequently trapped in the turbulent circulation, and the concentration profile is usually uniform throughout the cavity. This results in high pollutant concentrations at ground level. The plume of a stack which is below GEP stack height may become trapped in the wake region. A plume entrained in the wake region will be at a lower effective height than normal which will increase the ground level concentration in the area.

A cavity analysis was performed to assess the potential for pollutants to become trapped in the cavity region. The cavity analysis procedure was taken from Appendix C of Regional Workshops on Air Quality Modeling: A Summary Report. The procedure consists of four steps. The first step determines if the stack height is within the cavity region. If the stack height is above the cavity, the analysis is not required.

Step 1: Compare the stack height to the cavity height. The cavity height is calculated using the following equation:

$$h_c = H + 0.5\ (L)$$

where:

h_c	=	cavity height (m)
H	=	height of building (m)
	=	60.8 ft = 18.53 m
L	=	lesser dimension (height or projected width) of building.
	=	60.8 ft = 18.53 m

$$h_c = 18.53 + 0.5\ (18.85)$$
$$h_c = 27.80\ \textit{meters}$$

The effective stack height must be more than the cavity height to avoid the potential for the plume becoming trapped in the cavity region.

Step 2: Estimate the momentum plume rise for neutral atmospheric conditions. The momentum flux must be calculated. The following equation is used to calculate the momentum flux:

$$F_m = \frac{T_a}{T_s} \frac{v^2 d^2}{4}$$

where:

F_m	=	momentum flux
T_a	=	ambient air temperature, 293 K
T_s	=	stack exit temperature, 602.78 K
v	=	stack exit velocity, 15.03 m/s
d	=	stack inner diameter, 1.52 m

$$F_m = \frac{293}{602.78} \frac{15.03^2 \; 1.52^2}{4}$$

$$F_m = 63.72$$

The momentum plume rise is calculated with the following equation:

$$h_m = \left[\frac{3 \; F_m \; x}{b^2 \; u^2}\right]^{\frac{1}{3}}$$

where:

h_m	=	momentum plume rise, m
b	=	$(1/3 + u/v_s)$

u = critical wind speed, 7.5 m/s
x = downwind distance (assume two building heights), 37.06 m

$$h_m = \left(\frac{3 \times 63.72 \times 37.06}{0.83^2 \times 7.5^2} \right)^{\frac{1}{3}}$$

$$h_m = 5.66 \ meters$$

The plume height is calculated by adding the momentum plume rise to the actual stack height. This plume height must be greater than the cavity height (27.80 meters). When the plume height is greater than the cavity height it can be assumed that the dispersion will be dominated by wake effects and the further analysis in the cavity region is not required. In order for the plume height to be greater than the cavity height, the physical stack height must be greater than 22.14 meters (73 feet). This height is greater than the present stack height of 70 feet. Therefore, the stack height must be increased by a minimum of 3 feet to avoid any cavity effects (The actual increase will be determined by future modeling and NYDEC requirements). 91'

6. Dispersion Modeling

Because of the complex local terrain, both the Industrial Source Complex Short-Term Model (ISCST) and COMPLEX I in the "Valley equivalent" option will be used to estimate the maximum annual dispersion coefficient for the emissions from the incineration system. The output values from both models will be compared and the maximum value will be used in the risk analysis.

The ISCST model is recommended by the EPA for sites which do not have terrain rise above the stack. Any terrain height values which rise above the stack are truncated to a value slightly below the stack height during a model run. ISC is also recommended in the Guidelines on Air Quality Models for building wake calculations. The ISC model uses revised procedures to determine the effects of aerodynamic wakes and eddies formed by buildings on plume dispersion. Either the method of Huber and Snyder or those of Schullman and Scire are used, depending on the ratio of the stack height to the building height. Building downwash is a concern in this case because the NEPERA stack is not GEP stack height.

Guidelines on Air Quality Models requires the use of one year of on-site meteorological data with any second- or third-level screening technique in complex terrain. When on-site data is not available, a first-level screening technique must be used. There is no on-site meteorological data available for the NEPERA facility. Therefore, COMPLEX I will be used as a screening model to determine the dispersion coefficient in the complex terrain regions. COMPLEX I includes the plume impaction algorithm of the Valley model and contains a "Valley equivalent" option that uses worst case meteorological data. COMPLEX I is only recommended for receptor points which are above the plume height. For this reason both the ISCST model and the COMPLEX I model will be run for all receptors and the greater value will be used in the risk analysis. Both models will be run to determine the maximum annual and 1-hour ambient concentrations. The maximum 3-minute ambient concentration for Hydrogen Chloride will be calculated using the maximum 1-hour dispersion coefficient based on NYDEC recommendations.[2]

6.1 ISCST Input Parameters

The ISCST model defines some input settings to produce a simulation consistent with EPA regulatory recommendations. The following features are incorporated in the model when the regulatory default mode is used: